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AN ELASTICITY APPROACH TO FORECAST DYADIC TRADE AND ECONOMIC INTERDEPENDENCE

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13. ABSTRACT

Economic interdependence is defined as the relative proportion of a country's total trade with another country. To forecast economic interdependence in the 1985-1991 period, forecasts of dyadic trade must first be made. In the working paper, an elasticity approach is used to generate these forecasts. The income elasticity of imports for a particular country is defined as the ratio of the percent change in its imports divided by the percent change in its GNP. Import elasticities are important concepts of international economics and their use in forecasting economic interdependence is particularly useful since elasticities can yield future dyadic trade.

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I. INTRODUCTION

The development of an index which measures the central environmental descriptor economic interdependence is a two-stage process. The first stage is concerned with forecasting dyadic trade for various pairs of selected countries. This is necessary since economic interdependence is largely determined by the volume of trade between countries. The second stage involves calculating indices of economic interdependence using dyadic trade that has been forecast. Thus if one wishes to forecast the economic interdependence of France and Germany in 1985, one must first forecast trade between these countries for that year and then develop an index that measures the proportion of Germany's trade with France and vice versa. In this paper, the elasticity approach is used to forecast dyadic trade and the Michaely concentration ratio is suggested as a measure of economic interdependence.

By and large, arguments that explain the occurrence of trade can be divided into three groups: the classical theories, the Heckscher-Ohlin theory, and the modern theories. The classical economists, namely Adam Smith, David Ricardo, John Stuart Mill and their contemporaries including Marx, felt that international trade occurred when differences in production costs existed between countries.[1] These differences were thought to exist when different production techniques for the same products were employed by the trading nations. Differences in production costs were divided into absolute differences and relative or comparative differences. In the former case, if two countries produced two goods

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[1] For a good discussion of the forces behind international trade, see D. Snider, Introduction to International Economics (New York, 1954), pp. 13-25.

with one country more efficient in the production of one good and the other country more efficient in the production of the other good, then trade was said to benefit both. This example is illustrated by the following matrix which considers two countries, the U.S. and U.K., and two commodities, food and cloth. In this example, the U.S. is more efficient in food production while the U.K. is more efficient in cloth production.

TABLE 1

Case of Absolute Advantage*		
	Food	Cloth
U.S.	10	5
U.K.	6	13

*One labor-day produces respective units of food and cloth in each country

Ricardo and Mill refined the theory of absolute advantage and showed that specialization in production and trade would be beneficial even if the U.S. were more efficient in both food and cloth production. This meant that trade would benefit both countries as long as differences in relative or comparative costs existed. This is shown by the following matrix:

TABLE 2

Case of Comparative Advantage		
	Food	Cloth
U.S.	30	15
U.K.	15	10

*One labor-day produces respective units of food and cloth in each country.

The example indicates that the U.S. could outproduce the U.K. in both food and cloth production. Yet this is not the case since the U.S. would specialize in the production of food. This phenomenon arises because the price of cloth in terms of food is less in Britain (15/10 = 1.5) than in the U.S. (30/15 = 2). On the other hand, the price of food is less in America (15/30 + 0.5) than in the U.K. (10/15 = 0.7). Thus both countries could acquire more food and cloth if they would specialize and trade. For every unit of cloth the U.S. produces, it must give up 2 units of food; yet the British must give up only 1.5 units of food for every unit of cloth they manufacture. Thus, by specializing in food production, the U.S. would only need to pay the British 1.5 units of food for each unit of cloth. By trading, therefore, the U.S. would save half a unit of food which it could consume. Similarly, the U.K. would benefit by specializing in cloth production and exchanging cloth for food with the U.S.

The classical theory never successfully explained why differences in costs of production arose. It took another seventy years after Ricardo's death before two Swedish economists, Heckscher and his student Ohlin, developed the so-called factor proportion theory of international trade.[2] This theory states that differences in relative prices between countries exist because different countries are endowed with factors of production which are quantitatively and qualitatively distinct. A country tends to export commodities which use its abundant factors intensively and import goods which use its less-available factors. These differences reflect differences in production costs because the ratio of the price of capital to the price of labor is high in countries richly endowed with labor.

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[2] For a very thorough discussion of the Heckscher-Ohlin theory, see Harry G. Johnson, "Factor Endowments, International Trade and Factor Prices," The Manchester School of Economics and Social Studies (September 1957).

Thus differences in factor endowment are both necessary and sufficient conditions to explain the occurrence of trade. An important difference between the classical theory and the factor proportion theory involves production functions (or techniques of production). The modern theory assumes that production techniques for a particular commodity are similar the world over, though they may differ in factor intensity. The classical theory, on the other hand, assumes that different production functions exist between different countries. The former assertion is a reasonable assumption since multinational corporations have enhanced the transfer of technology between countries.

The modern theories of international trade are more concerned with the type of commodities that are traded given the presence of differences in comparative costs. Kravis, an American economist, believes that the commodity composition of trade is determined by the availability of various commodities at home.[3] Trade tends to be confined to goods that are not available domestically. There are basically two reasons for the absence of certain commodities in certain countries. First, these commodities, which are usually raw materials, may be non-existent in a particular country. Japan, for example, does not produce petroleum products because it is not endowed with oil deposits. Second, certain commodities which can be produced domestically are nevertheless imported because they can only be produced domestically at very high costs. The U.S., for example, could become self-sufficient in banana production. But since banana growing requires a tropical climate, the bananas would have to be grown under controlled climatic conditions in greenhouses. The cost of such an undertaking, in terms of other commodities that would have to be given up, makes banana growing in the U.S. prohibitive.

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[3] I. Kravis, "Availability and Other Influences on the Commodity Composition of Trade," Journal of Political Economy (April 1956).

II. THE SIGNIFICANCE OF THE ELASTICITY CONCEPT

In this paper economic interdependence is measured by the quantity of trade that takes place between countries. Countries i and j are said to be more economically interdependent than countries i and k if the former country pair trades more with each other than the latter country pair. In the forthcoming section, a procedure to forecast dyadic trade is presented.

A. THE ELASTICITY APPROACH

Elasticity is a mathematical property of a function. In economics, the concept of elasticity was developed by Alfred Marshall, an English economist of the late nineteenth century.[4] Marshall was originally concerned with developing a method to compare the responsiveness of buyers to price changes of different commodities. Thus the concept of price elasticity of demand was developed. Elasticity is a relative measure since it is expressed as a ratio of two percentages. The price elasticity of the demand for a commodity (x) was defined by Marshall as follows:

$$\text{(i)} \qquad E_1 = \frac{\%\ \Delta \text{ in } X}{\%\ \Delta \text{ in } Px} \ .$$

Thus if $\dot{E}_1 = .5$, then a 1% change in the price of commodity X (Px) will bring about a .5% change in the demand for X. Similarly, a 2% change in the price of X will bring about a 1% change in the demand for X.

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[4] For an excellent discussion of elasticity see P. Samuelson, Economics (New York: McGraw-Hill, 1961), pp. 411-431.

Equation (i) is usually written as:

$$\text{(ii)} \quad \frac{\Delta X}{\Delta Px} \cdot \frac{Px}{X} \cdot$$

The price elasticity concept has been extended by economists to the income elasticity concept which is symbolically written as:

$$\text{(iii)} \quad E_2 = \frac{\Delta X}{\Delta I} \cdot \frac{I}{X}$$

E_2 measures the responsiveness of changes in the demand for X, holding the price of X constant, to changes in the income (I) of the individual who is purchasing X. Thus if $E_2 = .6$, then a 2% rise in income will bring about a 1.2% rise in the demand for X.

III. ELASTICITIES AND INTERNATIONAL TRADE

Price and income elasticities have been widely used by economists to study the impact of price and income changes on the volume of international trade, i.e., the quantity of exports and of imports. In international trade, income elasticities of imports have been used to study the effects of economic growth (i.e., growth in GNP) on a country's balance of trade (exports minus imports). Price elasticities of imports, on the other hand, have been used to study the impact of devaluations on the balance of trade of national economies.

For the purpose of forecasting dyadic trade, the income elasticity of imports concept is utilized. Symbolically, the income elasticity of imports is written as:

$$\text{(iv)} \qquad E_3 = \frac{\Delta M}{\Delta GNP} \cdot \frac{GNP}{M}$$

This is equivalent to the percent change in imports divided by the percent change in national income or GNP, where M is total imports per time period of the country considered. If $E_3 = .9$, then a 10% change in domestic GNP will bring about a 9% change in the imports of the country for which the elasticity refers. Diagrammatically, the income elasticity of imports is drawn as follows:

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[5] In order to neutralize the impact of price changes on imports and to consider only the impact of changes in GNP on imports, all the variables in equation (iv) are expressed in constant monetary units.

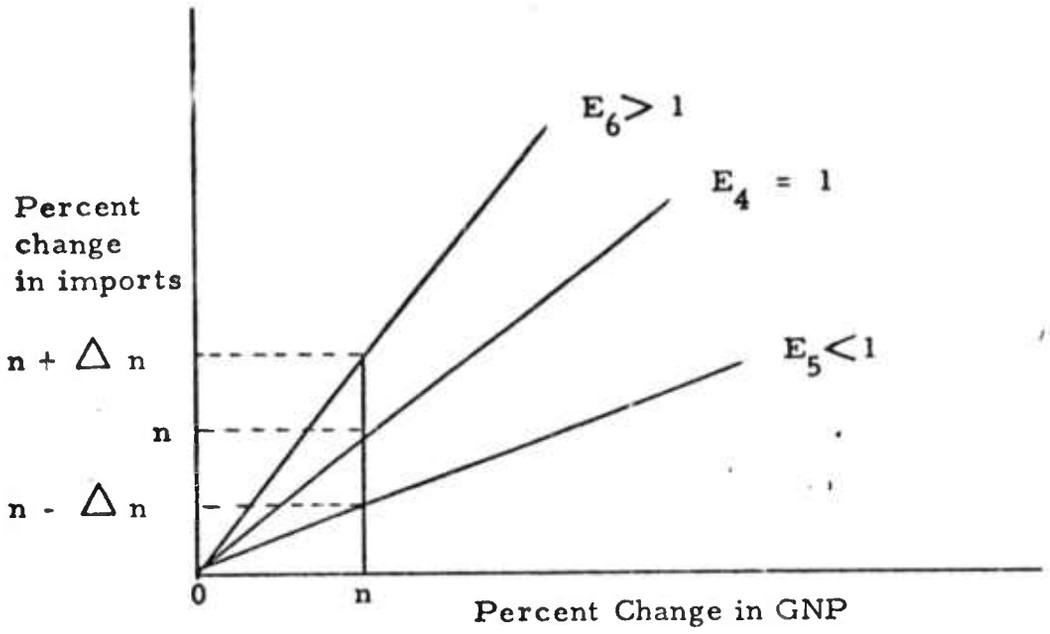

Figure 1.

To the left of E_4 the income elasticity of imports is greater than 1 which implies that a n percent change in GNP will bring about a more than proportional percent change in imports. To the right of E_4, the percent change in imports will be less than n, and on E_4 it will be exactly n.

A. DETERMINANTS OF IMPORT ELASTICITIES

Income elasticities of imports are determined by the composition of a country's trade, that is, by the predominant features of a country's exports and imports. Three general categories of traded product can be distinguished: industrial, agricultural, and raw material. Industrial countries, by and large, export manufactured goods and import foodstuffs and raw materials. Manufactured goods consist mainly of capital goods and high standard of living consumer goods which tend to have a high income elasticity. Agricultural goods consist mostly of food, the demand for which rises much slower than GNP, and thus have low income elasticities. The supply of raw materials has been declining over the last few decades

and the industrial countries undoubtedly will raise their demand for these products. For these reasons, income elasticities for raw materials which were once thought to be fairly low are higher than anticipated. Tastes of consumers which are affected by advertising or value judgments is another factor that influences the value of the income elasticity of imports. If, for example, French products are highly thought of in the U.S. because of their prestigious reputation, then the value of the income elasticity for French products will be greater than 1.

It can be seen, therefore, that the magnitude of the income elasticity of imports is determined by the types of commodities traded and by consumer tastes. Both these factors are fairly constant over the 15 to 20 year period of the forecast. Thus, it is fairly reasonable to assume that the Western economies will remain importers of food and raw materials and exporters of manufactured products over the foreseeable future. Moreover, it is also reasonable to assume that France, for example, will retain supremacy in perfume and wine manufacturing over the next twenty years. For these reasons, we can assume that income elasticities of imports are quite constant over time.

B. IMPORT ELASTICITIES TO FORECAST DYADIC TRADE

In the previous sections, the elasticity concept was developed. In this section, the use of the concept to forecast dyadic trade is explained via a hypothetical numerical example. Consider two countries, i and j. For country i, the income elasticity of imports from j is defined as:

$$(v) \qquad \frac{\Delta \text{Mij}}{\Delta \text{GNPi}} \cdot \frac{\text{GNPi}}{\text{Mij}} \cdot$$

For country j, the income elasticity of imports from i is defined as:

$$\text{(vi)} \qquad \frac{\Delta Mji}{\Delta GNPj} \cdot \frac{GNPj}{Mji} \cdot$$

The first ratio represents the percent change in the imports of country i from j (i.e., j's exports to i) divided by the percent change in the GNP of i. The second ratio represents the percent change in the imports of country j from i (i.e., i's exports to j) divided by the percent change in the GNP of j. If these elasticities, which are dependent on the composition of trade between i and j are constant over time, then future values of dyadic trade can be obtained, provided the GNPs of i and j can be forecast.

The following numerical example illustrates how such a forecast of dyadic trade can be generated. Assume the following elasticities to hold:

$$\frac{\Delta Mij}{GNPi} \cdot \frac{GNPi}{Mij} = 1.5 \text{ and}$$

$$\frac{\Delta Mji}{GNPj} \cdot \frac{GNPj}{Mji} = .9$$

Furthermore, assume that future values of the GNPs of i and j have either been obtained by some econometric technique or have already been estimated by the planning commissions of the two countries. The values of the GNPs are presented in Table 3.

TABLE 3

Future GNP Values of Countries i and j*		
Year	GNPi	GNPj
1973	115	51
1974	121	63
1975	138	71
1976	147	79
1977	158	86
1978	163	88

*in millions of U.S. dollars.

By calculating the percent change in the GNP of country i, we can estimate future values of imports of i from j as shown in Table 4. The table indicates that the exports of j to i will rise from $9.2 million in 1973 to $15.3 million in 1978.

TABLE 4

Forecast of Imports* of Country i from Country j				
Year	GNPi	% $\triangle$GNPi	% $\triangle$ Mij	Imports ij
1973	115	----	----	9.2
1974	121	5.2	7.8	9.9
1975	138	14.0	21.0	12.0
1976	147	6.5	9.7	13.2
1977	158	7.5	11.2	14.6
1978	163	4.6	4.6	15.3

*in millions of U.S. dollars.

In the same manner, the imports of j from i can be forecast. The values of these imports are presented in Table 5.

TABLE 5

Forecast of Imports* of Country j from Country i				
Year	GNPj	% △GNPj	% △Mji	Imports ji
1973	51	----	----	5.1
1974	63	23.5	21.2	6.2
1975	71	12.7	11.4	6.9
1976	79	11.3	10.2	7.6
1977	86	8.9	9.8	8.3
1978	88	2.3	2.1	8.5

*in millions of U.S. dollars.

The table indicates that the imports of country j from i (i.e., i's exports to j) will rise from $5.1 million in 1973 to $8.5 million in 1978.

By adding Mij to Mji, the total trade that will occur between countries i and j over the 1973-1978 period can be obtained. In this manner, the volume of trade between i and j can be compared to other dyads to derive indices of economic interdependence for all the dyads of interest. In the next section of the paper, the Michaely concentration ratio is suggested as a measure of economic interdependence.[6]

[6] M. Michaely, Concentration in International Trade (Amsterdam: North Holland Publishing Co., 1962).

IV. THE MICHAELY CONCENTRATION RATIO

This ratio was developed by Michaely in a treatise on international trade. Briefly, the index measures the proportion of a country's exports that go to another country. The index is expressed as follows:

$$Gix = 100 \sqrt{\sum_{j=1}^{n} \left(\frac{Mij}{Mi}\right)^2}$$

where: Mij represents the total imports of country i from country j per time period, and
Mi represents the total imports of country i per time period.

This index is a measure of the sum of the squared ratios of country i with all of its trading partners (j = 1, . . . n). The Michaely index measures the absolute ratios of a country's trade with other courtries. The upper limit of the ratio is 100 which indicates the highest trade concentration (i.e., all trade is undertaken with one country).

V. CONCLUSION

Forecasting economic interdependence is a two-step process. The first involves forecasting dyadic trade. This can be accomplished by employing the elasticity approach described earlier. The second step involves developing the economic interdependence index. This can be accomplished by employing the Michaely Concentration Ratio which is constructed from dyadic trade data.

The economic interdependence descriptor will be used to forecast values of other central environmental descriptors such as international conflict and international alignment. Moreover, future values of economic interdependence will be used in conjunction with alignment to generate values of a power base descriptor.